EWCE 333
Wastewater Engineering and Sanitation

Lecture 14

Instructor

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Lecture Outline

Topics	Reference
• Trickling Filter process – mechanisms and biological processes • Advantages, disadvantages, influencing factors in trickling filter process • Design of trickling filter	Water Supply and Sanitation - Feroz Ahmed and Mujibur Rahman ITN -BUET

Trickling Filter Process

- Trickling filters are fixed-growth biological beds where wastewater is spread on the surface of media supporting microbial growths.
- The media placed in a tank under the wastewater distributor can be crushed rock, plastic-sheet packing formed into modules, or random plastic packing of various shapes.
- Bacteria, fungi, and algae grow on the rock surface.

Trickling Filter Process

- As wastewater flows between the rocks, aerobic bacteria metabolize the organic material in the wastewater.
- As the biomass grows, the influent wastewater flow sloughs off the excess, which settles out in a secondary sedimentation tank.
- There is no recycling of sludge for a trickling filter, but there is usually a high effluent recycle ratio 300 to 500 percent of the influent flow is recycled from after the filter or sedimentation tank back to the filter.

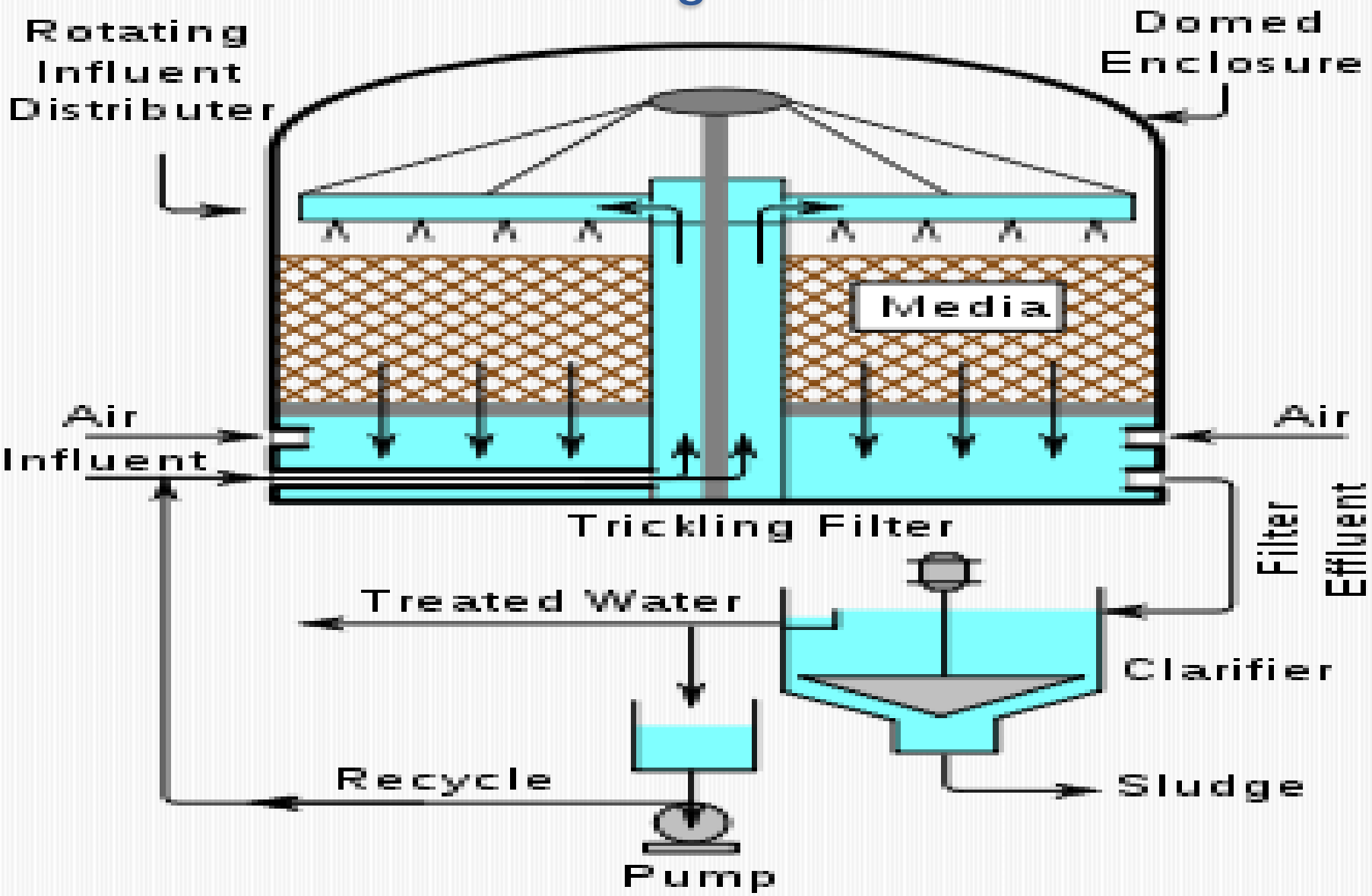
Components of Trickling Filter Media

(a) The Sewage Distributor

- It spreads the wastewater at a uniform hydraulic load per unit area on the surface of the bed.

- The arms are driven by the reaction of wastewater flowing out of the distributor nozzles, which usually requires a pressure head of 24 in. measured at the center column that supports the arms.

Trickling Filter



- Figure: Components of a typical Trickling Filter Media

Components of Trickling Filter Media

(b) The underdrain system

- The underdrain system may be composed of vitrified clay blocks with entrance holes to drainage channels
- It carries away the effluent and permits circulation through the bed.
- The need for free passage of air controls the size of openings in the underdrain.
- The filter media provide a surface for biological growth and voids for passage of air and water.

Components of Trickling Filter Media

(c) Filter media

- Traditionally, the common filter media have been crushed rock, slag, or field stone, since these are durable, insoluble, resistant to spalling, and often locally available.

- Stones, however, have the disadvantage of occupying the majority of the volume in a filter bed, thus reducing the void spaces for passage of air and limiting the surface area per unit volume for biological growth.

Components of Trickling Filter Media

- Several forms of chemical-resistant plastic media are available that have much greater surface area per unit volume and a large percentage of free space.

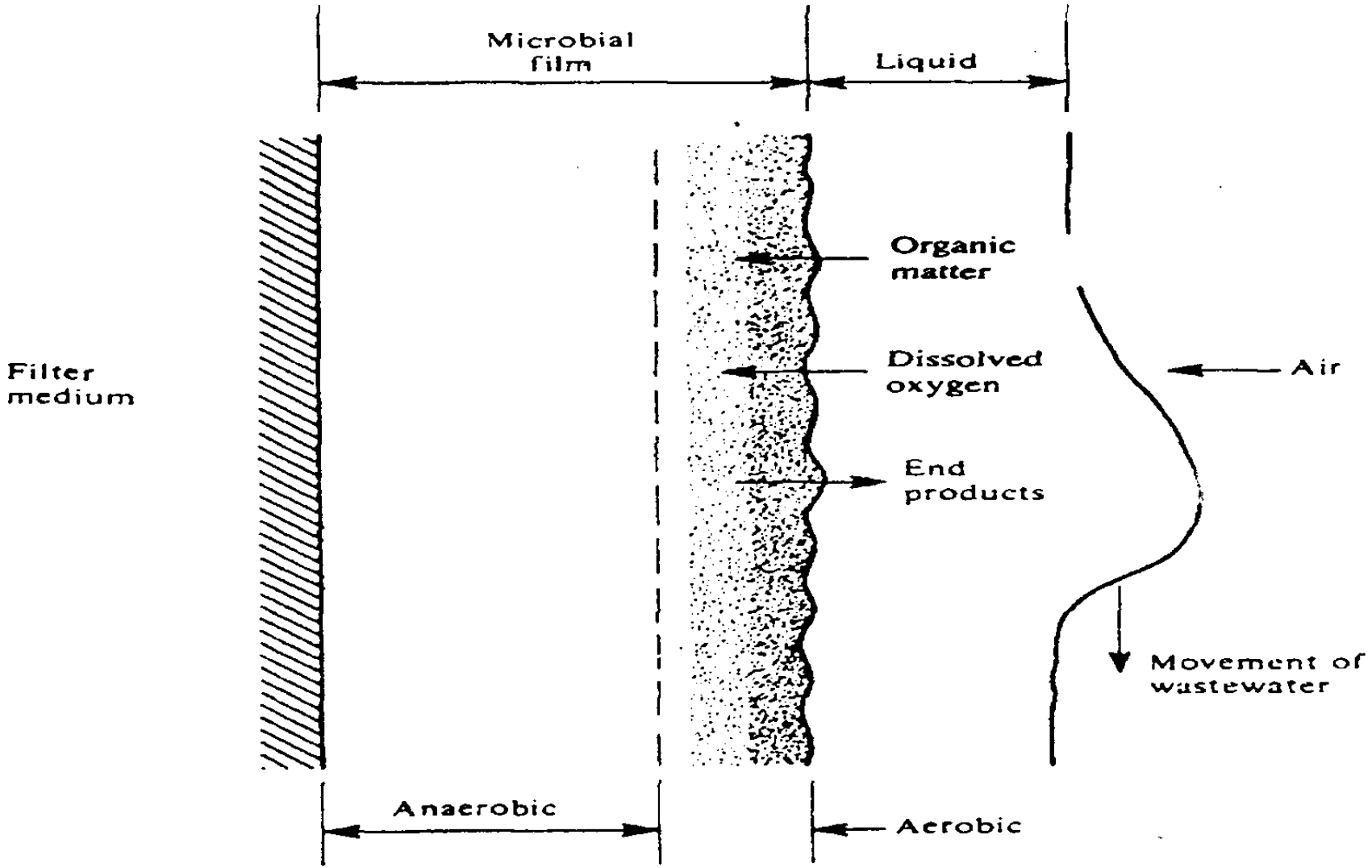
- For shallow filters, the common types are random packing and high density cross-flow media manufactured in comfortable modules that can be cut and fitted.

Biological Process in Trickling Filtration

(a) Formation of Biological Slime layers

- Filter media is aerobic to a depth of only 0.1-0.2 mm.
- The zone adjacent to the medium is anaerobic.
- The slime layers consist of bacteria, protozoa, and fungi. Frequently, noticeable populations of larger organisms such as sludge worms and rotifers are present.

Biological Process in Trickling Filtration



Schematic diagram showing the form of the biological process in a trickling filter.

Biological Process in Trickling Filtration

- The top surface of a bed exposed to sunlight is coated with algae, and lower portion of a deep filter can support nitrifying bacteria.

- Microorganisms near the surface of the bed where the food concentration is high are in a rapid growth phase, while the microorganisms near the bottom are in a state of starvation.

Biological Process in Trickling Filtration

(b) Biological Metabolic Action

- As the wastewater flows over the microbial film, the soluble organic matter is metabolized and the colloidal organic matter is adsorbed on the film.

(c) Supply of O_2

- Dissolved oxygen taken up in the liquid layer is replenished by re-oxygenation from the surrounding air.

- Continuous passage of air through the bed is essential to prevent undesirable anerobic conditions.

Physical Factors influencing Trickling Filtration

- **Media configuration** - Several forms of manufactured media provide a high specific surface area with a corresponding large percentage of void volume. This permits substantial biological growth without inhibiting passage of air through the bed.

- **Bed depth** - A uniform medium also allows even loading distribution, and light weight packing permits the construction of deep beds.

- **Hydraulic loading**

Advantages of Trickling Filter

- Simplicity
- Low operating cost
- Production of a waste sludge that is easy to process.

Disadvantages of Trickling Filter

- Poor effluent quality and emission of offensive odors, both associated with organic loading, industrial wastes, and cold-weather operation.

- The anaerobic zone of the film adjacent to the medium surface can produce odorous metabolic end products. If they are not oxidized while moving through the aerobic zone, they can be released and carried out in the airflow through the bed.

- Some industrial wastes have characteristic odors that are not easily oxidized by the microbial film.

Disadvantages of Trickling Filter

- Ponding results from sloughings due to excessive organism growth.

- Filter Flies

- Degradation of final effluent due to excessive loading from sloughings on final sedimentation tanks.

Effluent BOD from Trickling Filter

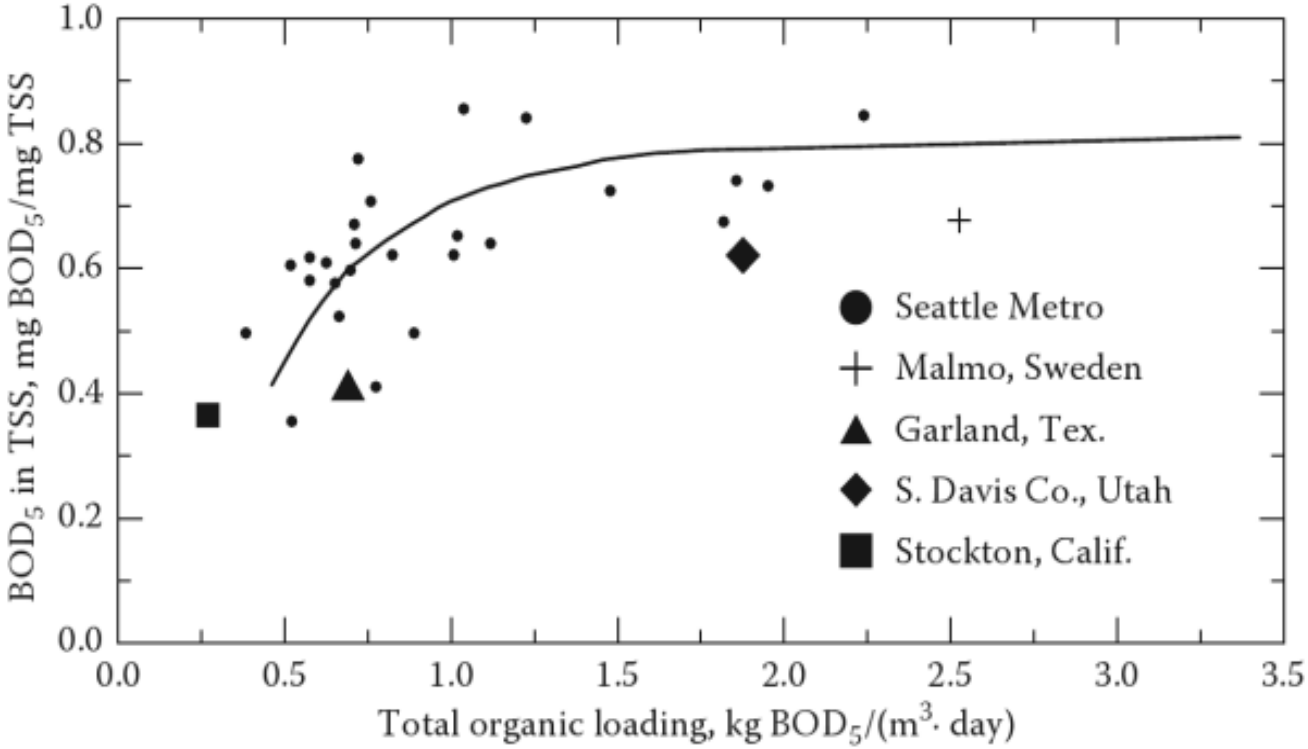


FIGURE 19.9 Effect of total organic loading (TOL) on the BOD_5 of suspended solids leaving a trickling filter. (From Water Environment Federation, *Design of Municipal Wastewater Treatment Plants*, Manual of Practice No. 8, Water Environment Federation, Alexandria, Virginia, 1992. Copyright © Water Environment Federation, Alexandria, Virginia. Reprinted with permission.)

Ref: Biological Wastewater Treatment (3rd ed.)–
By C. P. Leslie Grady, Jr., Glen T. Daigger, Nancy G. Love, Carlos D. M. Filipe

Estimation of Effluent BOD from Trickling Filter

Example 19.2.9.1

A trickling filter receiving a wastewater with a total BOD_5 of 150 mg/L achieves 90% removal of soluble BOD_5 by being operated at a TOL of 0.75 kg $BOD_5/(m^3 \cdot day)$. What will be the BOD_5 of the clarified effluent if it contains 30 mg/L of suspended solids? Assume that the soluble BOD_5 concentration of the influent wastewater is 65% of the total BOD_5.

a. First calculate the soluble BOD_5 in the effluent.
   The soluble BOD_5 in the influent wastewater is $(0.65)(150) = 97.5$ mg/L. Since 90% of it is removed, the soluble BOD_5 concentration in the trickling filter effluent is 9.75 mg/L.
b. Next estimate the BOD_5 due to particulate matter in the effluent.
   Entering Figure 19.9 with a TOL of 0.75 kg $BOD_5/(m^3 \cdot day)$, it can be seen that the BOD_5/TSS ratio is 0.5. Since the suspended solids concentration in the effluent is 30 mg/L, the particulate BOD_5 is $(0.5)(30) = 15$ mg/L.
c. The total BOD_5 is just the sum of the soluble and particulate BOD_5 values.
   Total $BOD_5 = 9.75 + 15 = 24.75$ mg/L.

Estimation of Effluent BOD from Trickling Filter

Velz formula:

$$C_e = \left(\frac{C_i + rC_e}{1 + r} \right) e^{-kD}$$

where,

C_e = Effluent BOD, mg/L

C_i = Influent BOD, mg/L

r = Ratio of recirculated flow to wastewater

D = Depth of filter, ft

K = Velz decay rate,

= 0.175 ft^{-1} for low rate filters and

= 0.1505 ft^{-1} for high rate filters (operated at 20°C)

Temperature correction for, K

$$\mathbf{K_T = K_{20°C}\ (1.047)^{T-20°C}}$$

Estimation of Effluent BOD from Trickling Filter

Velz formula

- Gave the first semi-theoretical analysis of trickling filter performance vs depth of filter media.

- Useful in predicting BOD removal fraction for any generic trickling filter, especially with synthetic media.

Estimation of Effluent BOD from Trickling Filter

Problem

Calculate the effluent BOD from a trickling filter having a depth of 2 m and a re-circulated rate of 125 percent of the flow. The influent BOD is 170 mg/L following primary treatment.